

### 3.5 Annex V – Electric and Hybrid-Electric Vehicle Development

The automotive industry is one of the main industries in China and is expanding rapidly. Because of its importance to the domestic economy, the auto industry receives support from the Central Government. The government support emphasizes both production capacity increases and product quality improvement. As a result, car production capacity is expected to reach 1.2 million units in 2000 and triple that by 2010. On the other hand, increasing the number of automobiles will aggravate the environmental and energy problems of China. Motor vehicles are a major source of air pollution in major Chinese cities, and their contribution is increasing. In Beijing, for example, mobile sources accounted for 39% of the carbon monoxide, 75% of the hydrocarbons, and 46% of the nitrogen oxide emissions in 1989 [19]. Since then the motor vehicle use and traffic congestion have increased, prompting the government to focus attention on the research and development of electric vehicles (EV) and hybrid-electric vehicle technologies.

Annex V to the Protocol Agreement, titled “Electric Vehicle and Hybrid-Electric Vehicle Development,” was signed on November 18, 1997. Initial meetings were held in December 1997 in Washington, D.C.; the U.S. Annex V Team visited Beijing in early August 1998, held further discussions with representatives of the Ministry of Science and Technology, and visited electric vehicle research facilities and automotive manufacturing facilities in China. At these sessions both sides agreed to emphasize information exchange in four major areas:

- ♦ **Technology Transfer:** Coordination on basic public domain technology with emphasis on standards development and testing methods. The emphasis is on creating a high level of technical excellence and autonomy in the Chinese advanced vehicle technology programs. U. S. experience shows the importance of these activities to a sound program.
- ♦ **Implementation:** Coordination on basic implementation policy and practice issues. U. S. experience in conducting accelerated implementation programs will be applied as appropriate to the rapidly developing Chinese vehicle market. New forums will broaden the exchange of information and ideas needed to accelerate the development, manufacture, and deployment of advanced technology vehicles in China.
- ♦ **Environmental Protection:** Coordination on the basic elements of deploying advanced technology vehicles in an environmentally acceptable manner. This includes assuring that the Chinese government and industry take appropriate measures to implement safe transportation, in-vehicle use, and recycling or reclamation of advanced technology components and subsystems.
- ♦ **Development of Small Business Opportunities:** Coordination on developing opportunities for small businesses to work with the Chinese automotive industries on critical technology needs for advanced vehicles. Small business opportunities will be created through a variety of mechanisms, such as small business set-asides, similar to those already established in the United States.

The U.S. Annex V Team recognized the ambitious nature of the Chinese program and the many technical and political issues. Both sides agree on the overall need to make progress at a faster rate and encourage more industry involvement. Facilitating information exchange and private sector business activity is considered to be an appropriate role for the Team. Consequently, open workshops and demonstration projects are expected to be important tools used in the agreement. The overall U.S.-China program faces these same issues.

In technology transfer, opportunities will be sought for interchange of researchers or joint projects between Chinese and U. S. research laboratories. The interchanges are expected to emphasize advanced batteries and fuel cell technology. In 1999, web site development is planned to disseminate information on EV and hybrid-electric vehicles. Further emphasis will be sought on links between private businesses to conduct appropriate programs with Chinese government and business entities. Where appropriate, the DOE will work with Chinese institutions to seek international bank and development organizations' funding and other support for projects in China.

### 3.5.1 Technology Description and Background

China has been expanding development of its automotive industry in the transportation sector. This development includes the petroleum industry which supplies traditional transportation fuels such as gasoline and diesel fuel. However, there is increasing concern with the economic and environmental impacts of growing fossil fuel use, especially the increased use of imported fuels. In 1993, China became a net oil importer. Imports continue to grow in spite of efforts to employ enhanced oil recovery techniques to older fields and to develop offshore reserves in the South China Sea and promising new areas in western China – in particular the remote Tarim Basin in the Taklamakan Desert. New pipelines were completed to that site, next to another smaller, but less remote, area in the Turpan-Hami, or Tuha, Basin.

Air pollution from automobiles is an increasing problem in urban areas. Ambient hydrocarbons, carbon monoxide, and ozone concentrations in major cities exceed Chinese standards and are attributed primarily to mobile sources—especially automobiles. Although the number of vehicles in Beijing is only one-tenth of that in Los Angeles and Tokyo, vehicle emissions are about the same for all three cities [1,19].

China's automotive sector is considered a 'pillar industry,' part of the centrally planned economy. The sale, servicing, and use of automotive vehicles for transporting people and goods is increasingly in the private sector. Automotive manufacturers are shifting emphasis away from production of heavy trucks and buses, these being about 65 percent of the total fleet in 1990. Light duty personal vehicles, especially privately owned passenger vehicles, are the fastest growing segment with this segment of the fleet more than doubling from 1990 to 1995 compared to the prior five year period. See Table 4.

International business development is expanding in the automotive sector. Under joint ventures with American, European, and Japanese firms, new manufacturing and assembly plants are now operating in China. General Motors was one of the companies invited to build an automotive assembly plant in China (for small Buicks). Chrysler, through a joint venture in the Beijing Jeep Factory, is currently producing about 100,000 vehicles with more than 80% of the components manufactured in China.



Figure 16. Traffic congestion and air pollution in Beijing

Research on electric and hybrid-electric (and alternative fuel) vehicles is an area of expanding interest in China. In 1996, the EV project became one of the National Science and Technology Projects. Currently, part of the research

Table 4. Registered Civilian Vehicle Fleet is Growing Quickly

Type of Vehicle/Owner	1985	1990 (thousands)	1995	Average annual growth 1985-95 (percent)
Passenger vehicles	795	1,622	4,179	18
Professional Transport	83	108	131	5
Privately Owned	19	241	786	45
Trucks	2,232	3,685	5,854	10
Professional Transport	194	198	142	-3
Privately Owned	265	573	1,226	17
Other	616	411	1,227	7
Total	3,643	5,718	11,260	13

Sources: World Bank and China statistical Yearbook 1996.

program is focused on Lithium-Ion and Nickel-Metal-Hydrate batteries and on fuel cells. EV testing and demonstration areas have been established in Shantou-Nanao and seventeen EVs have been tested for two years. The integrating design of the prototype EV is continuing and there have been some important achievements in the design of key parts. According to the plan, the Electric Concept Vehicle will be completed and demonstrated in 2000.

Currently, an economic evaluation of developing Hybrid EV technology is under way, to ensure the resulting concepts are practical. As low-pollution or no-pollution vehicles, EVs are expected to be the important transportation tool in the 21st century. China plans to attract the world's advanced technology and deploy some new vehicle technology in creative ways.

### 3.5.2 Work Plans Under Development

Several technical discussion meetings have been held in the U.S. and China in an effort to develop work plans. In 1998, a DOE/industry delegation visited electric vehicle research facilities at Tsinghua University and the Chinese Academy of Science. This delegation also visited the Beijing Jeep plant, and met with MOST and the multi-organizational electric vehicle team. Areas for cooperation were discussed. The areas of possible cooperation focused on the following topics:

**Battery Management and State-of-Charge Controllers**—Tsinghua University, Delphi-Automotive Institute, provides broad interdisciplinary technical training in management skills needed for a modern automotive industry. The University's Departments of Automotive Engineering and Computer Science and Technology have produced a number of converted electric vehicles, including an electric bike, a 4-



Figure 17. Chevrolet S-10 electric vehicle in commercial demonstration program in China

passenger electric car, and a 16-passenger electric bus using DC motors, DC controllers, and flooded (tubular) lead acid batteries. Also, joint work is being done with General Motors in the U.S. on battery management systems and state-of-charge indicators.

**AC Motor Control Systems** – Chinese Academy of Sciences, Institute for Electrical Engineering is developing AC motor control systems for use in the Chinese electric vehicles in the 50 kW range. The research group is examining different motor types: induction motors, permanent magnet synchronous motors, and switched reluctance motors. This could lead to joint venture opportunities to produce the power switches or micro controller chips.

**Standards Development** – China is working on standards development in four areas: overall vehicle systems, controllers and motors, batteries, and battery charging. This is very similar to the approach used in the U.S. by the Society of Automotive Engineers, and industry in both U.S. and China can benefit from mutually compatible standards.

**Electrochemical Technology on Batteries and Fuel Cells** – China is working on a number of advanced electrochemical technologies that are also being developed in the U.S. This includes work on nickel metal hydride and lithium ion batteries for electric vehicles and possibly on proton exchange membrane fuel cells. Possible assignments and exchange of scientific personnel between National Laboratories in both countries is being discussed.

**Technology Transfer** – The technology transfer areas represent agreements that came out of the first meeting under Annex V in December 1997. These areas were:

1. Organization of current U.S. Federal Government programs – DOE provided general information for use in structuring Chinese electric vehicle programs.
2. Fast charging – DOE provided a general technical information report on this topic based on work completed in this area by the U.S. firms AeroVironment and Norvick.
3. AC motor controllers – DOE provided general reports about the status of AC motor controllers in the U.S. and encouraged possible cooperation with U.S. small businesses in this field including: Unique Mobility and AC Propulsion.

**Implementation** – The U.S. team is providing technical assistance in planning the implementation and management processes. Prior work was reviewed, including the 1995 study “Encouraging Purchase and Use of Electric Motor Vehicles” and the 1997 “Electric Utility Participation Study.” Other major U.S. implementation programs, including Clean Cities and the Electric Vehicle Ready Cities program were also reviewed. China is considering doing similar studies and implementation programs.

**Environmental Protection** – Both countries are concerned about avoiding the possibilities of creating new or unexpected environmental problems as a result of introducing new vehicle technologies. Cooperation can be beneficial to insuring that all important environmental issues are considered. One area of cooperation is on environmental assessments which were done for advanced batteries by the NREL, as well as, the ongoing work of the Advanced Battery Readiness Working Groups and the Infrastructure Working Council. Cooperation could lead to Chinese participation in appropriate international working groups on international standards for abuse testing and other topics relating to advanced batteries.

**Small Business Roles** – There is interest in possible participation by United States small businesses in planning China’s electric vehicle program.